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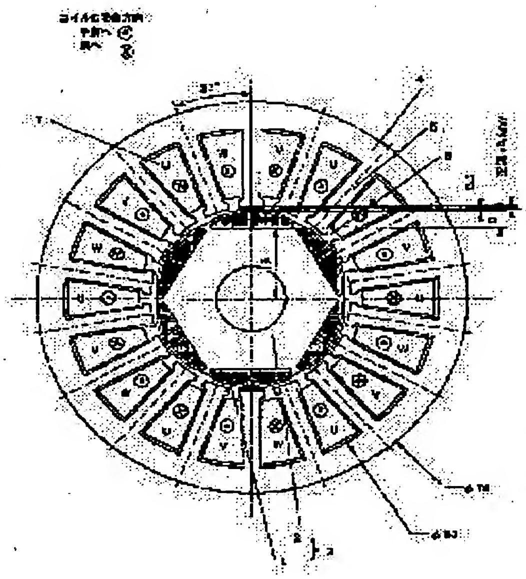
(54) PERMANENT-MAGNET MOTOR

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a permanent-magnet motor having a magnet buried type rotor, in which cogging torque is reduced, and a high output and high accuracy are controlled.
SOLUTION: In the permanent-magnet motor in which a rotor 3, in which a plurality of permanent magnets 1 are buried into a rotor yoke 2 in the radial direction, and a stator, in which windings are wound on a core with a plurality of slots 6, are arranged through an air gap, the motor has the petal-shaped rotor 3 in which the center of an outside diameter is made eccentric so that the outside diameter passing through the external contour of the permanent magnet 1 is made smaller than that passing through the apex of the contour of the adjacent permanent magnet 1.



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CLAIMS

[Claim(s)]
[Claim 1] The permanent magnet motor characterized by to have the petaloid rotator to which eccentricity of the core of an outer diameter was carried out so that the outer diameter which passes along the outside profile of said permanent magnet might become smaller than the outer diameter passing through the top-most vertices of the profile of an adjoining permanent magnet in the permanent magnet motor which has arranged the rotator by which two or more permanent magnets were embedded inside rotator York in the radial direction, and the stator which coiled the coil around the iron core which has two or more slots through an opening.
[Claim 2] The permanent magnet motor characterized by having the petaloid rotator to which the outer diameter which passes along the outside profile of said permanent magnet carried out eccentricity of the core of an outer diameter so that it might become smaller than the outer diameter passing through the top-most vertices of the profile of an adjoining permanent magnet, and it carried out eccentricity to more than magnetic thickness in claim 1.
[Claim 3] The permanent magnet motor according to claim 1 or 2 by which there were more than one, and the shaft orientations of a rotator shifted the permanent magnet gradually to the hoop direction, and have arranged it to it to each shaft orientations.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the permanent magnet motor of synchronous system, such as a servo motor and DC brushless motor.
[0002]
[Description of the Prior Art] Since effectiveness is high and a permanent magnet motor has the good controllability, it is used for the motors for control including a servo motor. For example, the permanent magnet motor of a radial air gap form as shown in drawing 2 R> 2 is used for the AC servo motor. The permanent magnet motor shown in drawing 2 is constituted from a stator which consists of a coil 17 wound around the rotator 12 which stuck the permanent magnet 10 of C form on the radial direction, and the stator yoke 13 which has two or more slots 15 arranged through an opening (gap) and teeth 14 by the front face of the rotator yoke 11. In the case of the permanent magnet motor shown in drawing 2 , the number of 6 and teeth of the pole of a permanent magnet is 18, and the arrow head in a permanent magnet shows the direction of magnetization of a permanent magnet. Moreover, as the coil was shown in drawing 3 , three-phase-circuit Y connection is made by the distribution volume, and the numbers of turns of a coil are 30 turns per one slot.
[0003] By the way, the pulsation of torque, such as an AC servo motor which needs the torque control of high degree of accuracy, must be small. Therefore, when a permanent magnet rotates, it is not desirable that a torque ripple occurs by pulsation of the cogging torque (torque in the condition of not passing a current in a coil) and induced voltage which originate in magnetic-flux distribution of an opening changing from the physical relationship of the slot of a stator and a permanent magnet. A torque ripple worsens a controllability and also causes noise.
[0004] As an approach of reducing cogging torque, as shown in drawing 4 R> 4, there is an approach using the permanent magnet to which eccentricity of the core of the outer diameter of the permanent magnet of C form or D form was carried out so that the end shape of a permanent magnet 20 may become thin. By this approach, magnetic-flux distribution in the permanent magnet edge of a magnetic pole with a big change of magnetic-flux distribution which it changes and is a part becomes smooth, and cogging torque can be reduced. In addition, 21 are a rotator yoke among drawing 4 .
[0005] As an option which reduces cogging torque, the skew of the armature (stator) yoke is carried out, or there is an approach which has ****ed the skew of the permanent magnet of a rotator enough, and carries out it. A skew means the condition that the revolution joined the hoop direction according to the location of shaft orientations. If a skew is applied to an armature (stator) yoke, since the skew of the laminating steel plate must be carried out, and it must be accumulated, or winding must be stored in the stator slot which carried out the skew and a process will become troublesome, the approach of carrying out the skew of the permanent magnet 30 of a rotator like drawing 5 generally, and fixing is taken. As for the angle of skew (AOB) 33 at this time, 1/2 and 1 time of the slot pitch of a stator are usually chosen. In addition, as for 31, a rotator yoke and 32 are shafts among drawing 5 R> 5, and A is [the center point of a lower permanent magnet end face and O of the center point of a upside permanent magnet end face and B] shaft centers.
[0006] However, by the permanent magnet motor which stuck the permanent magnet on the front face of a rotator yoke as shown in drawing 2 with adhesives etc., there is a possibility that a permanent magnet may separate and disperse from a rotator during a revolution according to the centrifugal force which joins a permanent magnet. Consequently, a permanent magnet will be caught in a gap and a permanent magnet motor will carry out a quick stop. For example, when the worst [this kind of motor is used for electric power steering of an automobile, and], a steering will lock, steering will become impossible and it will be concerned with it at a human life. Then, in order to prevent, as it is shown in drawing 2 that a permanent magnet separates from a rotator, the nonmagnetic sleeve 16 which consists of aluminum etc. is put on a permanent magnet front face, or heat curing of the tape which the epoxy resin was made to **** is twisted and carried out to a glass fiber. However, if a sleeve or a tape is made not much thick, since a motor output will be lowered, it cannot be said that the reinforcement which, as for thickness, presses down a permanent magnet although 0.1 to about 0.3mm is chosen is enough. There is reinforcement, and the sleeve or tape of thin meat has a high manufacturing cost, and leads to the cost rise of a permanent magnet motor.
[0007] Moreover, as rotator structure where a permanent magnet does not disperse, as shown in drawing 6 , there is a magnet embedding mold rotator which embedded the permanent magnet 40 to the interior of the rotator yoke 41. A magnet embedding mold rotator yoke pierces a silicon steel plate with an about 0.5mm electromagnetic steel sheet, carries out the laminating of this and produces it. By improvement in a punching technique in recent years, the fabrication cost of this magnet embedding mold rotator yoke is not high. However, since this type of rotator is embedded inside in the permanent magnet, the effect which it has on the magnetic-flux distribution on the front face of a rotator has the configuration of a permanent magnet smaller than the surface magnet mold shown in drawing 2 . Therefore, since the magnet embedding mold rotator could not fully reduce cogging torque by changing the configuration of a permanent magnet, it had the problem of generally becoming bigger cogging torque than a surface magnet mold rotator.
[0008]
[Problem(s) to be Solved by the Invention] The object of this invention is to offer the permanent magnet motor of the high power high-degree-of-accuracy control which has the rotator of the magnet embedding mold which reduced cogging torque.
[0009]

[Means for Solving the Problem] the permanent magnet motor which has the rotator of the anxious magnet embedding mold with which this invention person inquires wholeheartedly in order to solve the above-mentioned technical problem, and a permanent magnet disperses, and which is not -- the following -- amelioration was added and the smooth revolution without torque unevenness was realized. That is, this invention is the permanent magnet motor characterized by to have the petaloid rotator to which eccentricity of the core of an outer diameter was carried out so that the outer diameter which passes along the outside profile of said permanent magnet might become smaller than the outer diameter passing through the top-most vertices of the profile of an adjoining permanent magnet in the permanent magnet motor which has arranged the rotator by which two or more permanent magnets were embedded inside rotator York in the radial direction, and the stator which coiled the coil around the iron core which has two or more slots through an opening.
[0010]
[Embodiment of the Invention] Hereafter, this invention is explained to a detail with reference to a drawing. The description of this invention is in the point of having the petaloid rotator to which eccentricity of the core of the outer diameter of a rotator was carried out so that the outer diameter which passes along the outside profile of a permanent magnet might become smaller than the outer diameter passing through the top-most vertices of the profile of an adjoining permanent magnet in the permanent magnet motor which has a magnet embedding mold rotator, as described above. It is specifically having the petaloid rotator which was made to carry out eccentricity of the core of an outer diameter so that it may become smaller than the outer diameter by which the outer diameter which passes along the outside profile of said permanent magnet passes along the top-most vertices of the profile of an adjoining permanent magnet, and carried out eccentricity to more than magnetic thickness. And this becomes the smooth revolution without torque unevenness, and cogging torque is reduced. As the permanent magnet motor of this invention is shown in drawing 1 , the rotator 3 has structure which embedded the permanent magnet 1 magnetized with N pole and the south pole by turns in the radial direction to the interior of the rotator yoke 2. Although the configuration of a permanent magnet 1 serves as a cross section of D form in drawing 1 , as shown in drawing 7 (b) and (c), it is good also as C form or a rectangle. The stator of the point arranged through the rotator 3 and the opening which consists of a stator yoke 4 which has two or more slots 6 as a configuration of others of a permanent magnet motor, and a coil 7 wound around teeth 5 is the same as that of the conventional example of drawing 2 . In addition, the pole of a permanent magnet of the permanent magnet motor illustrated to drawing 1 is 6, and the number of teeth is 18.
[0011] As shown in drawing 1 , the outer diameter which passes along the outside profile of a permanent magnet makes the shape of surface type of a rotator 3 the petaloid made smaller than the outer diameter passing through the top-most vertices of the profile of an adjoining permanent magnet. As shown in drawing 7 (a), specifically in each magnetic pole, eccentricity of the core of the outer diameter of a rotator yoke is carried out. Moreover, since the magnetic flux of a permanent magnet will connect too hastily within a rotator yoke and the utilization effectiveness of a permanent magnet will fall if the part to which the rotator yoke which becomes the outside of a permanent magnet becomes the thinnest is too thick, the thickness of about 0.5mm usually indispensable for scattering prevention of a permanent magnet is chosen. Furthermore, the cause of cogging torque is a magnetic pole's changing and enlarging die length between the adjoining magnetic poles which are parts, since it originates in magnetic-flux distribution of an opening changing by physical relationship with the slot of a stator when a permanent magnet's rotates as explained previously, change of opening magnetic-flux distribution decreases and cogging torque can be reduced. Moreover, as a desirable mode of this invention, there are two or more shaft orientations of a rotator, and cogging torque can be reduced more by shifting a permanent magnet gradually to a hoop direction, and arranging it to it to each shaft orientations.
[0012]
[Example] Hereafter, an example explains in detail. In addition, although the permanent magnet of a Nd-Fe-B system is explained, this invention is not restricted to a Nd-Fe-B system magnet. The permanent magnet was manufactured at the following processes. Using with a purity [of 99.7 % of the weight of purity / Nd, Fe, Co, M (M is aluminum, Si and Cu), and 99.5 % of the weight of purity] B, dissolution casting was carried out with the vacuum melting furnace, and the ingot was produced, respectively. Coarse grinding of this ingot was carried out with the jaw crusher, and the impalpable powder of 3.5 micrometers of average grain shapes was further obtained by jet mill grinding in a nitrogen air current. This impalpable powder is set all over the magnetic field of 12kG(s) with a vertical magnetic field press, and it is 1.0 t/cm2. It fabricated with moulding pressure. This Plastic solid performed sintering at 1090 degrees C among Ar gas for 1 hour, and performed heat treatment of 1 hour at 580 degrees C succeedingly. Then, the grinding process by the grinding stone was performed and C form permanent magnet was obtained. The properties of this permanent magnet were Br:13.0kG, iHc:15kOe, and (BH) max:40MGOe.
[0013] (Example of a comparison) The cogging torque of the permanent magnet motor of the surface magnet mold of the dimension shown in drawing 6 whose depth of a rotator and a stator is 30mm as an example of a comparison, and when rotating a permanent magnet motor at a fixed rate, without switching on a power source (the permanent magnet motor was used as the generator), the induced voltage (Electric Motive Force) generated between the lines of three-phase-circuit winding was measured. In addition, as the coil 46 was shown in drawing 3 by the arrow head in drawing 6 and in a permanent magnet 40 showing the direction of magnetization of a permanent magnet, three-phase-circuit Y connection is made by the distribution volume, and the numbers of turns of a coil are 30 turns per one slot. Cogging torque fixed the shaft of a permanent magnet motor to the torque detector, and measured the torque when rotating one side of a shaft at the rate of ten or less rpm carried out slowly by another permanent magnet motor. It will be the amount of magnetic flux interlinked in the coil per unit time amount, and if induced voltage EMF fixes a rotational frequency and it is compared, it will be a value proportional to driving torque. The rotational frequency was measured as 1000rpm this time. The permanent magnet of the permanent magnet motor shown in drawing 6 carried out eccentricity of the outer diameter in order to aim at reduction of cogging torque. Furthermore, like drawing 4 , the permanent magnet was divided into two at shaft orientations, and the skew was performed. The include angle of a skew was made into 20 degrees for one slot of a stator. There are an increase and the point with which cogging torque will become small if it carries out about eccentricity, and this eccentricity was set to 4mm. Cogging torque and the value of induced voltage are shown in a table 1. Cogging torque is a difference of wave-like maximum and the minimum value to ripple, and induced voltage is actual value. Although desired value was set to 0.006Nm by the high-degree-of-accuracy control permanent magnet motor since 1% or less of the rating torque of cogging torque was desired value and the rating torques of the example of a comparison were 0.63Nm / 3000rpm, the cogging torque of the example of a comparison did not carry out clear [of the desired value] by 0.041Nm. In addition,

since the permanent magnet motor of the conventional example shown by drawing 2 could not fully perform magnetic scattering preventive measures, the comparison was not carried out.
[0014] (Example) As an example, as shown in drawing 1, the cogging torque and induced voltage of a permanent magnet motor whose rotator is petaloid were evaluated. The eccentricity to which the dimension and angle of skew of a permanent magnet presuppose that it is the same as that of the conventional example, the configuration of a rotator yoke should be drawing 7 (a) Shown, and eccentricity of the core of the outer diameter of a rotator yoke was carried out in each magnetic pole was 4mm. The cogging torque of an example carried out clear [of the desired value] by 0.003Nm. Furthermore, since the yoke thickness of the outside of a permanent magnet was thin compared with the example of a comparison, there were few short circuits of magnetic flux and EMF's improved.
[0015]
[A table 1]

	コギングトルク（Ｎｍ）	誘起電圧（ｍＶ／ｒｐｍ）
実施例	０．００３	９．３０
比較例	０．０４１	８．１１

[0016]
[Effect of the Invention] As explained above, scattering prevention of the permanent magnet from a rotator and reduction of cogging torque are attained by this invention, it is useful to high-performance-izing and the improvement in dependability in AC servo permanent magnet motor, DC brush loess permanent magnet motor, etc., and the utility value is very high on industry.

[Translation done.]

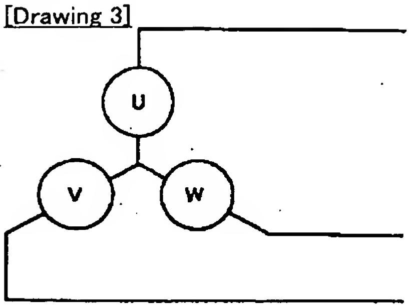
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view of the permanent magnet motor of this invention.
[Drawing 2] It is the sectional view of the permanent magnet motor of the conventional example.
[Drawing 3] It is the explanatory view having shown the stator winding.
[Drawing 4] It is drawing which carried out eccentricity of the core of a permanent magnet outer diameter for cogging torque reduction.
[Drawing 5] It is the explanatory view of the skew of cogging torque reduction performed for accumulating, and (a) is a sectional view and (b) is a front view.
[Drawing 6] It is the sectional view of the magnet embedding mold rotator of the example of a comparison.
[Drawing 7] It is the sectional view of a magnet embedding mold rotator where the magnet configurations of this invention differ, and in (a), D form and (b) show C form, and (c) shows the case of a rectangular permanent magnet.
[Description of Notations]
1, 10, 20, 30, 40 Permanent magnet
2, 11, 21, 31, 41 Rotator yoke
3, 12, 42 Rotator
4, 13, 43 Stator yoke
5, 14, 44 Teeth
6, 15, 45 Slot
7, 17, 46 Coil
16 Sleeve
32 Shaft
33 Angle of Skew

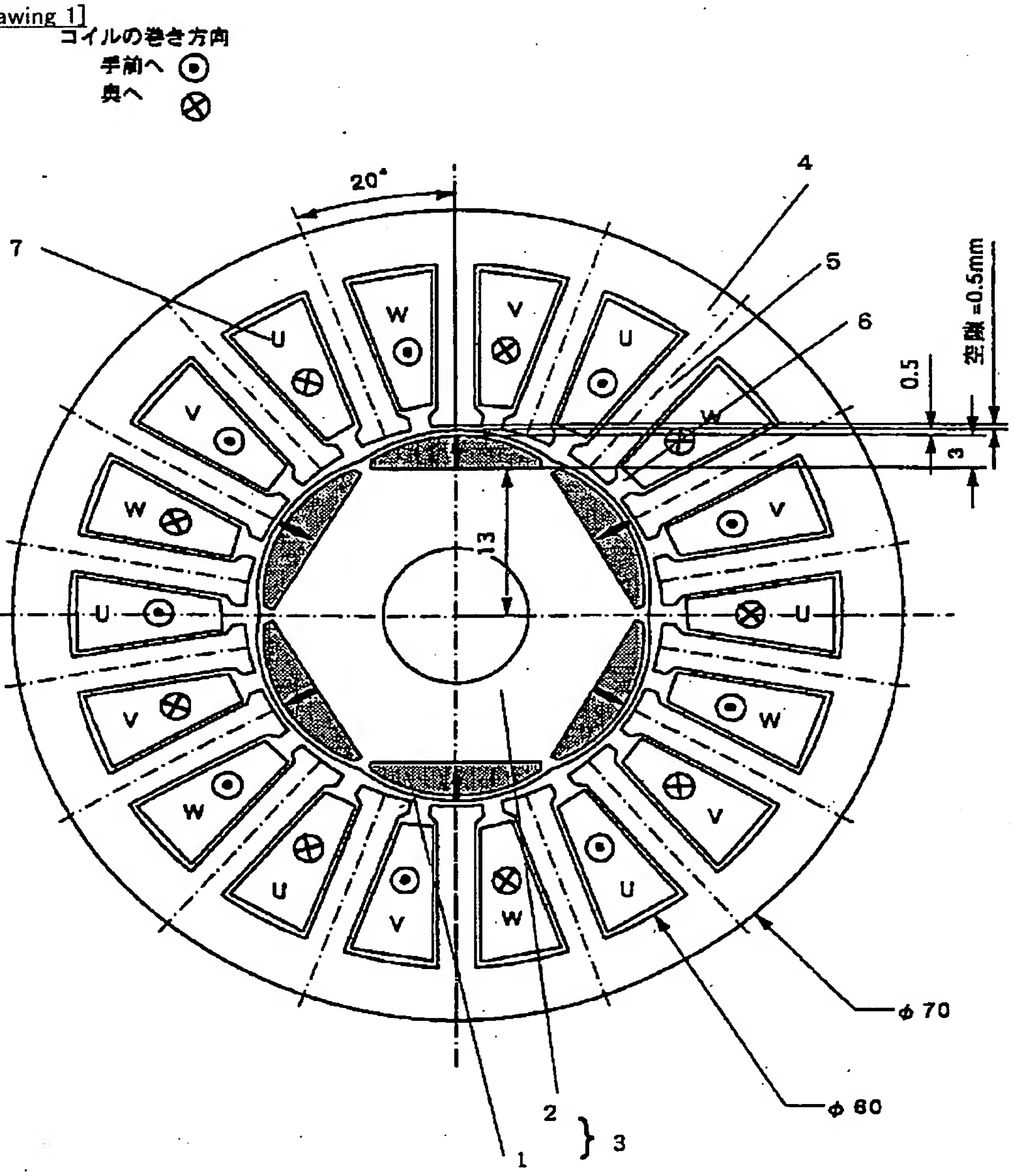
[Translation done.]

DRAWINGS

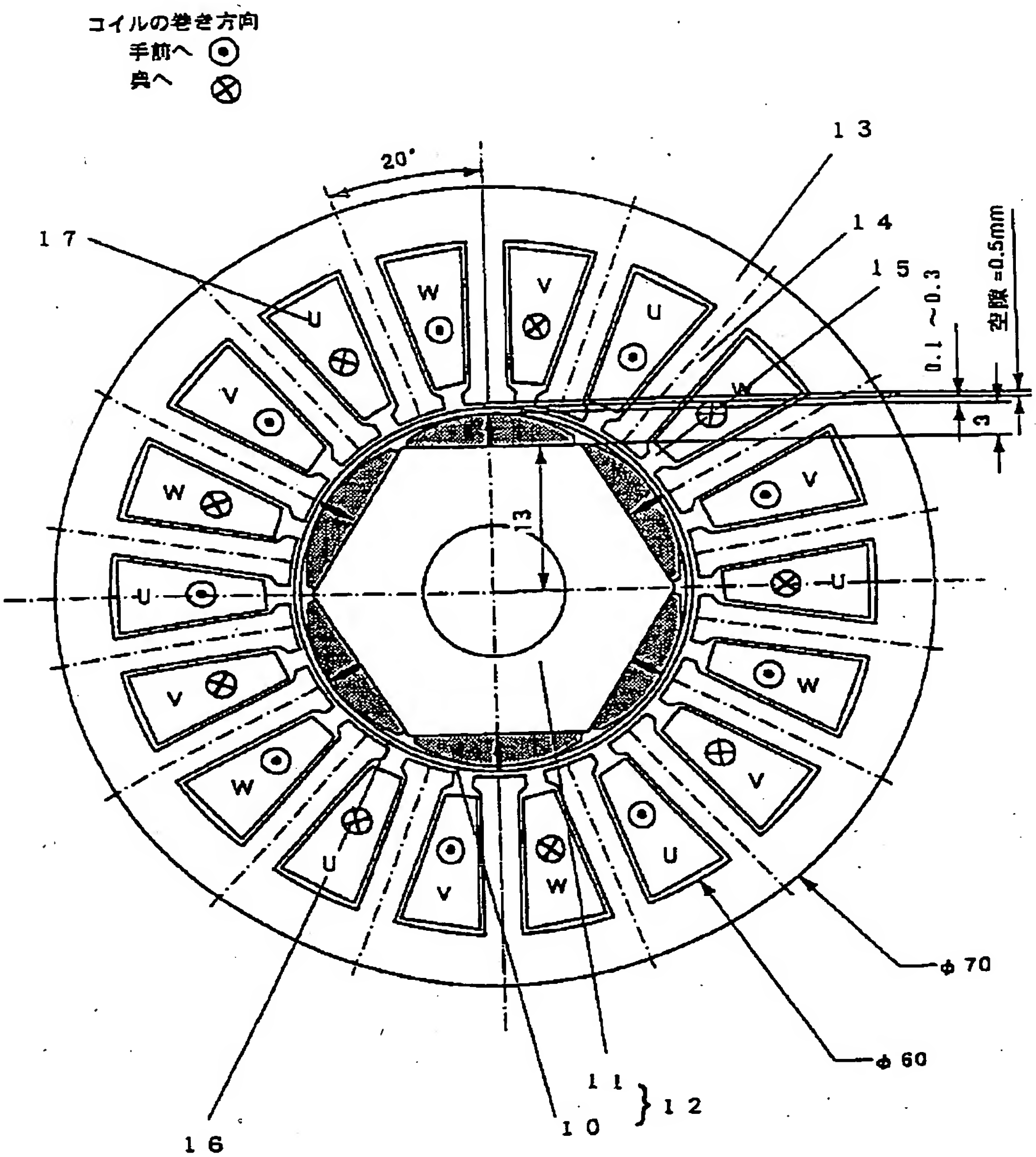
[Drawing 3]



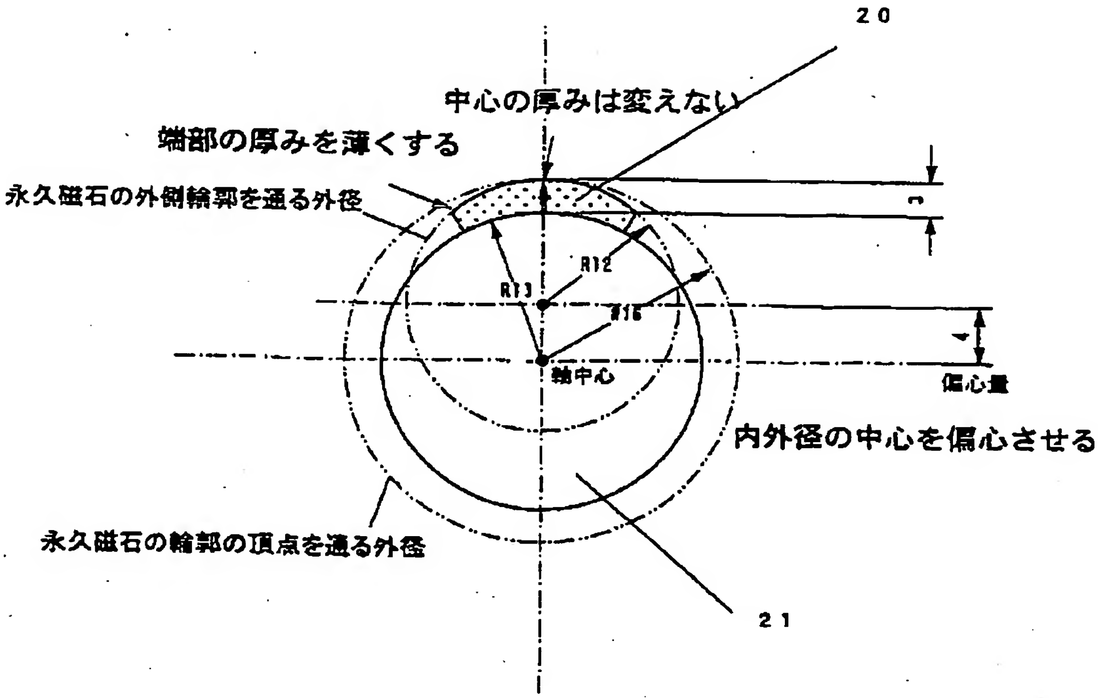
[Drawing 1]



[Drawing 2]


コイルの巻き方向
手前へ
奥へ
20°
１３
１４
１５
１７
0.1～0.3
空隙=0.5mm
3
13
φ70
φ60
１６
１０
１１
１２

[Drawing 4]



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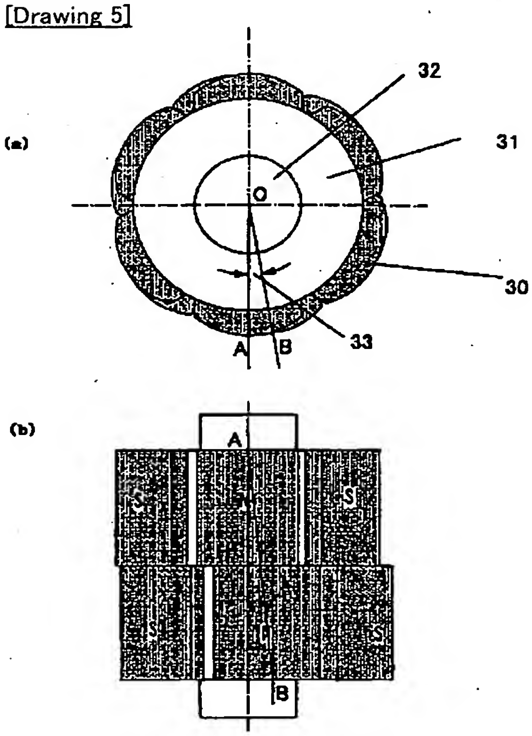
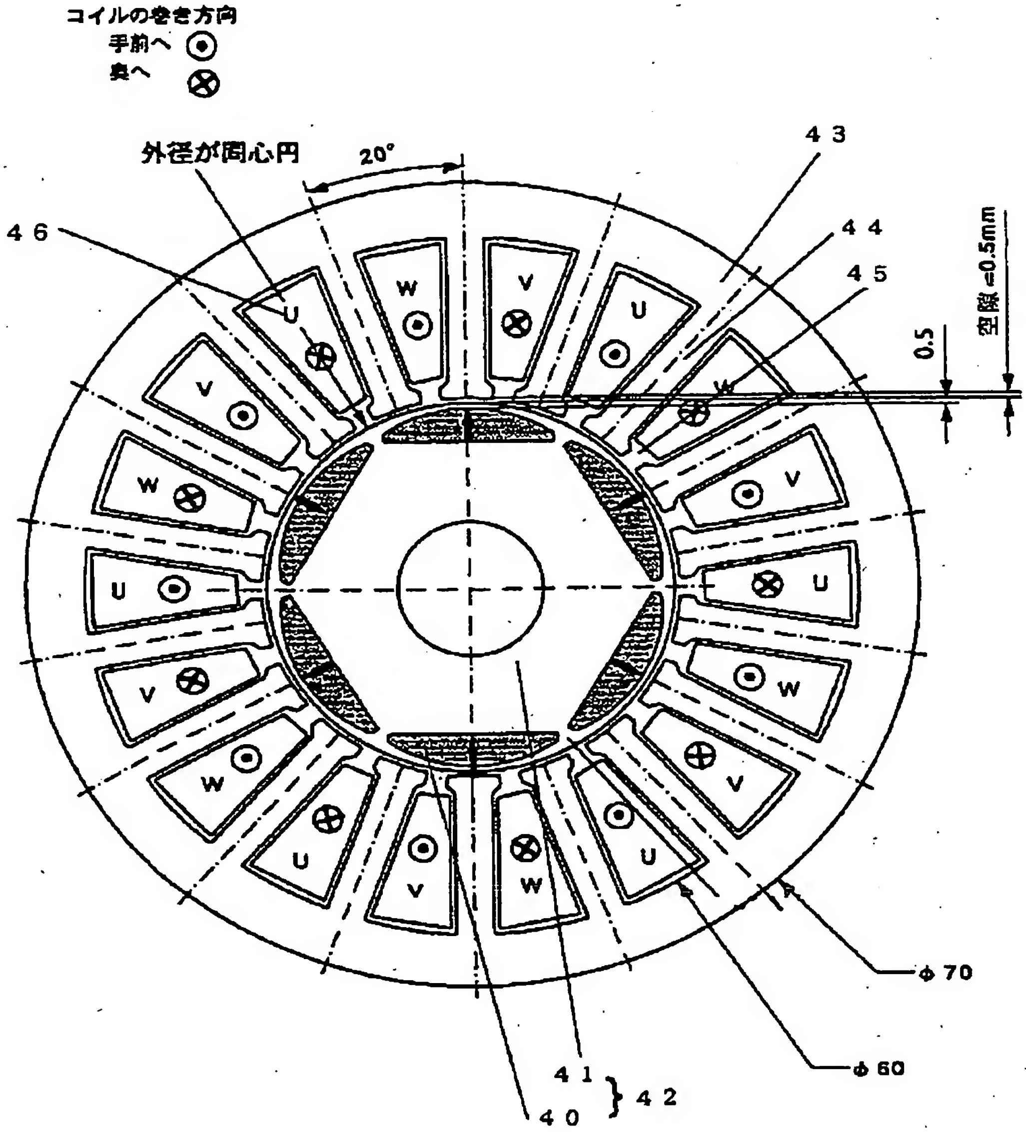
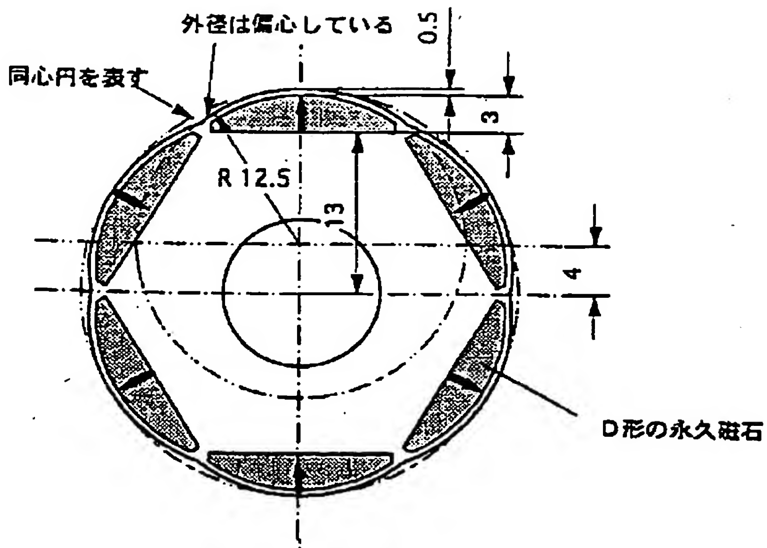


[Drawing 6]

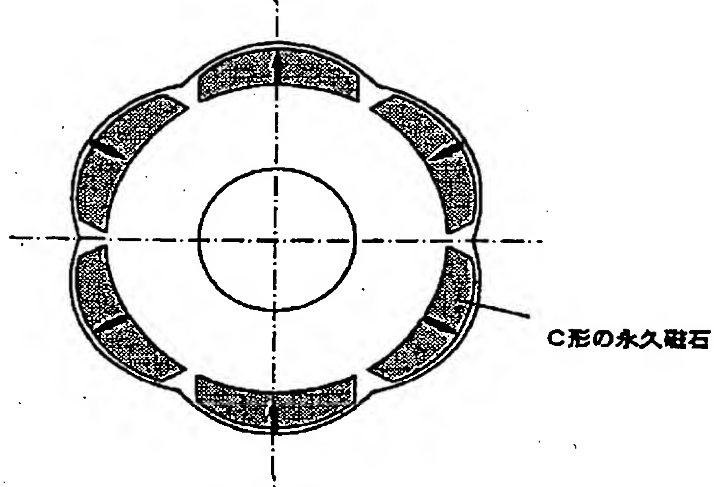

コイルの巻き方向
手前へ
奥へ
外径が同心円
20°
4 3
4 4
4 5
4 6
0.5
空隙 =0.5mm
U
V
W
φ 70
φ 60
4 1
4 2
4 0

[Drawing 7]

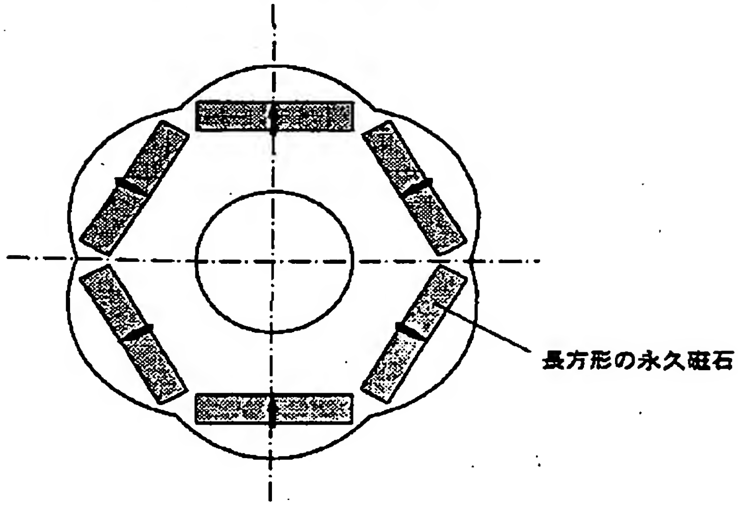
(a)



(b)



(c)



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